RELAP5 SEMINAR 2005

Downcomer modeling options for LOFT experiment L2-5. Sensitivity analyses

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Summary

- 1. Introduction
  - 1.1 L2-5
  - 1.2 Previous studies

- 2. Present calculations
  - 2.1 Nodalization
  - 2.2 Approach

- 3. Results
  - 3.1 Blowdown peak
  - 3.2 Core Quenching

- 4. Conclusions

1. Introduction 1/2

The purposes of this study are:

- To complete the understanding of the involved phenomena in a LB-LOCA scenario
- To study the effect of 3D downcomer nodalizations on cladding temperature
- To evaluate the significance of 1D / 3D related parameters
- To establish guidelines to improve BEMUSE base case calculation

1. Introduction

BEMUSE (BE Methods – Uncertainty and Sensitivity Evaluation) project deals with:

- the use of methodologies developed for uncertainty analysis of results obtained in computational simulations

- in an international framework (OECD)

- LBLOCA

- Its phases 2 and 3 (out of 6) are related to LOFT L2-5

- September 2003 / end 2007

1.1 L2-5

L2-5 experiment is a Large Break Cold Leg LOCA

- LOFT facility
- 200% double guillotine break
- HPIS and LPIS injections are delayed to simulate a loss of site power
- In BEMUSE phase 3 (recently submitted), participants have applied their proposed UM to LOFT L2-5 simulation.
- In phase 2 sensitivity calculations had been performed by means of arbitrary variations in selected input variables

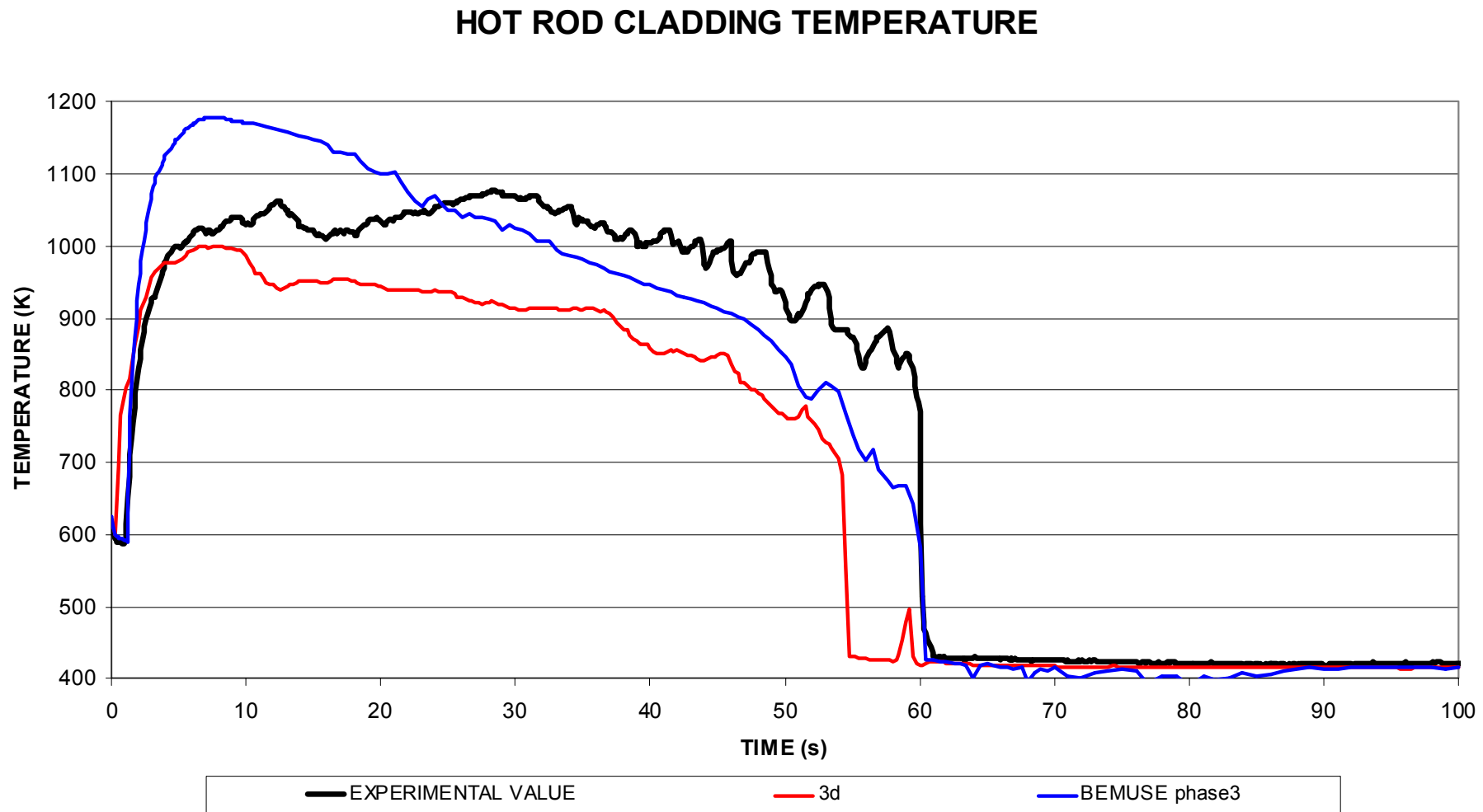# 1.2 Previous studies (1/3)

In previous UPC studies L2-5 experiment was simulated with:

- 3d nodalization (RELAP5-3D INEEL input deck, heat structures **not** finely detailed)

- 1d nodalization; UPC contribution to BEMUSE phase 3:
  - in the framework of BEMUSE, UPC has used a RELAP5/MOD3.3 1d-model of LOFT
  - it includes very detailed core heat structures, according to the specifications document used in phase 2 of the BEMUSE program.

Those studies pointed out the possibility of improvement.

1.2 Previous studies (2/3)

HOT ROD CLADDING TEMPERATURE

1.2 Previous studies (3/3)

What can be improved?

- Our goal is to obtain sound conclusions on the 1d/3d issue after comparing calculations using different noding options.

- The results of the previous studies can not be strictly compared since they were performed with different nodalization features (active core heat structures among others) and different code versions.

- In the present analysis, RELAP5-3D is used with both 1D and 3D input models so that analysis and comparison are meaningful.

2. Present calculations

- A downcomer study has been carried out with the aim of improving the UPC results in the BEMUSE project.

- Two base input decks (INEEL) have been used:

    - 1d nodalization with a split downcomer

    - 3d nodalization

- Both cases have the same heat structures; furthermore, they have the same BOP nodalization (RPV noding is the sole difference)
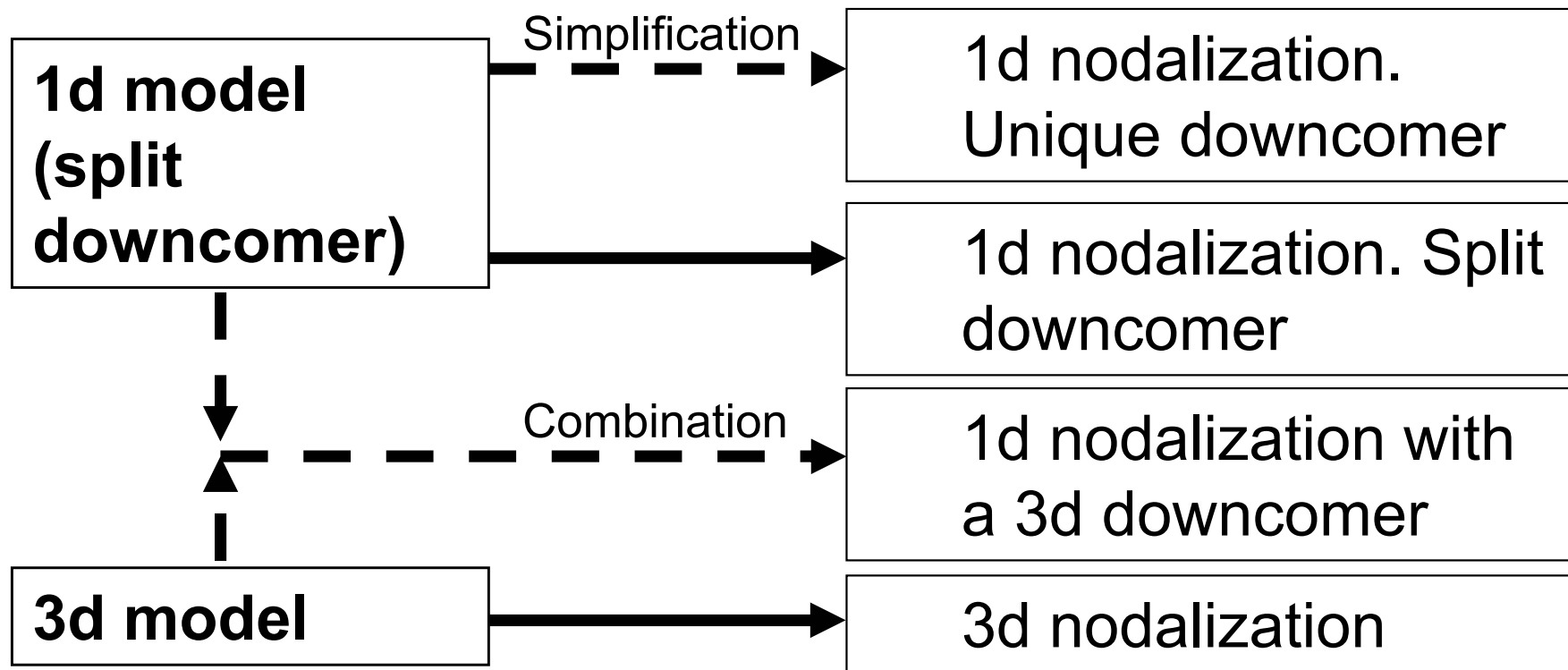
2.1 Nodalization features (1/4)

- Heat structures implemented by UPC in the models are those proposed in BEMUSE phase 2 and are based on L2-5 experimental data

- Heat structures used divide the active core in 4 zones, according to its radial position:

  - Peripheral zone

  - Average zone

  - Hot zone

  - Hot rod

2.1 Nodalization features (2/4)

- Four nodalizations, obtained from the two base input decks, were compared:

1d model (split downcomer)	Simplification ⇢	1d nodalization. Unique downcomer
	→	1d nodalization. Split downcomer
	Combination ⇢	1d nodalization with a 3d downcomer
3d model	→	3d nodalization

2.1 Nodalization features (3/4)

ACTIVE CORE

1d (pipe)
- 12 axial nodes

3d (multi dimensional component)
- 12 axial nodes
- 3 radial zones
- 4 azimutal sections
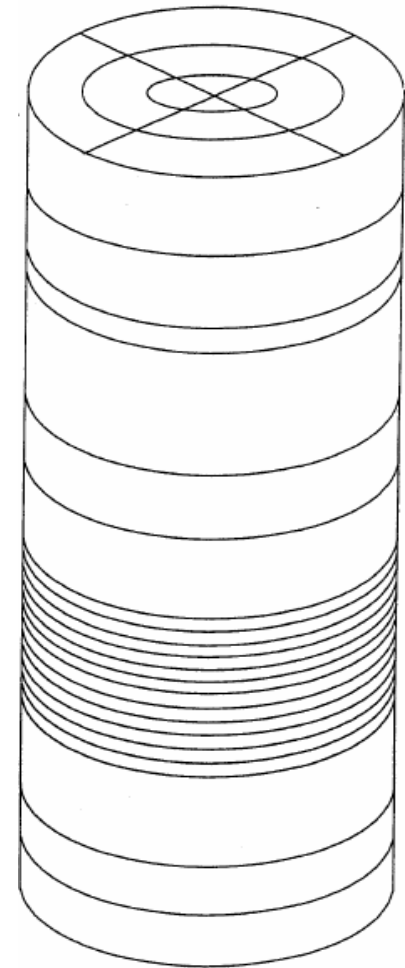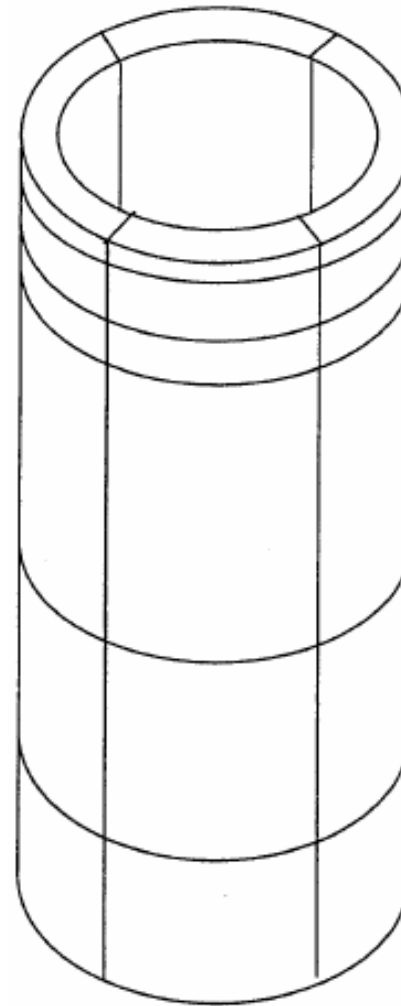
2.1 Nodalization features (4/4)

DOWNCOMER

1d
- Unique
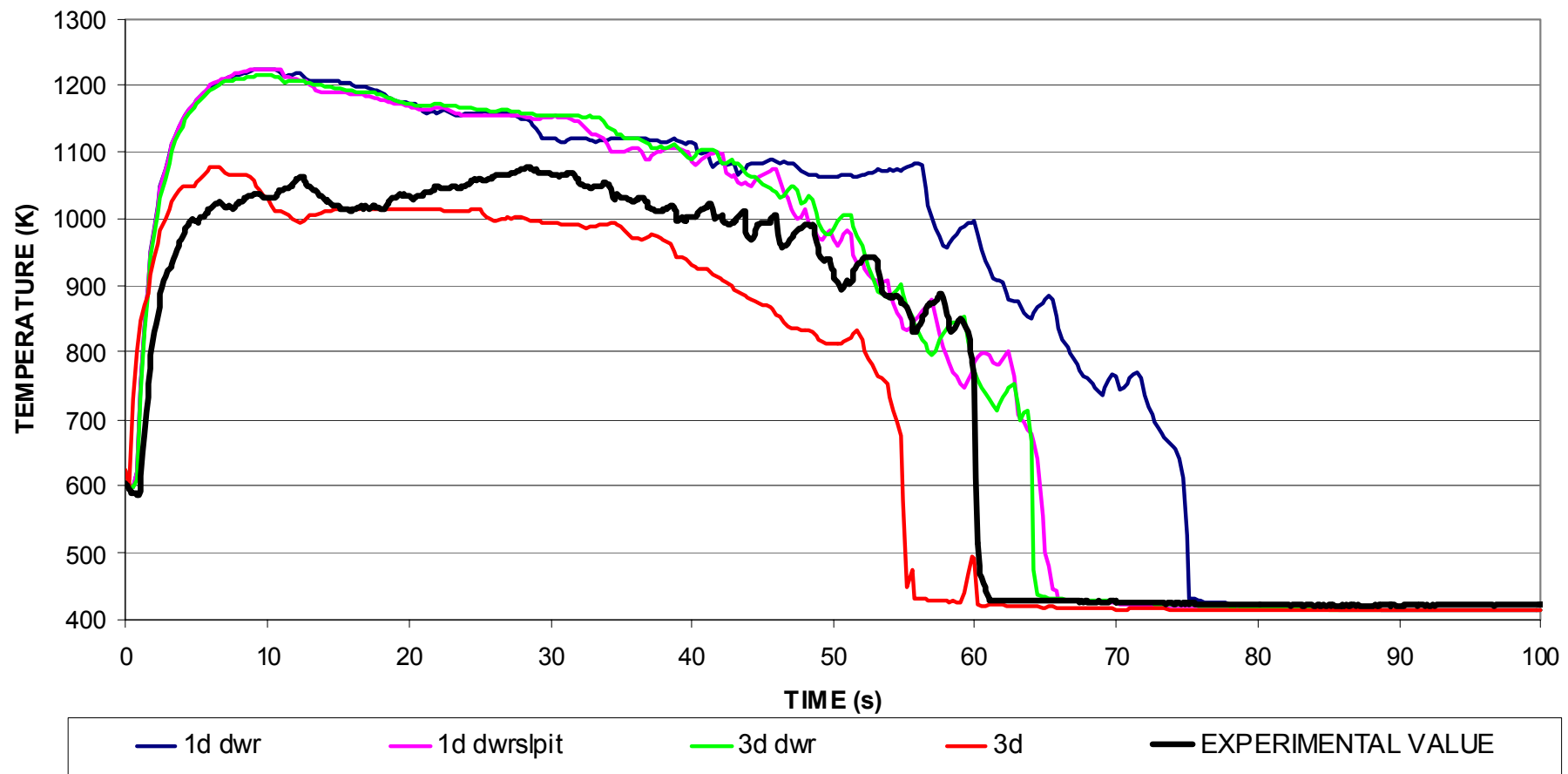- Split (broken and intact loops)

3d (multi dimensional component)
- 6 axial nodes
- 1 radial zone
- 4 azimutal sections
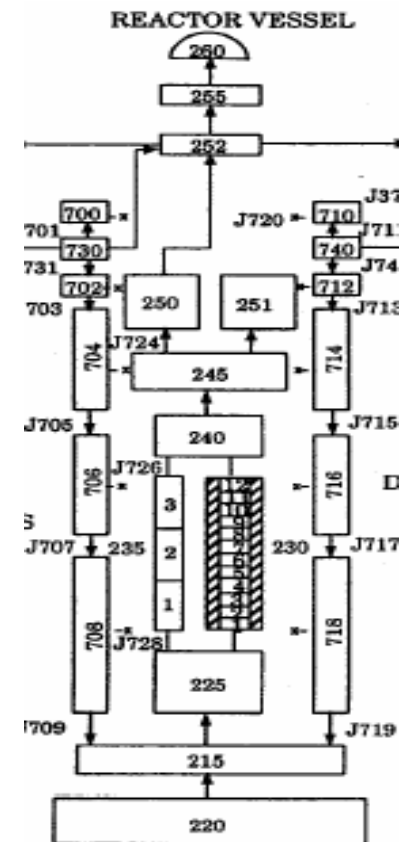
2.2 General approach (1/2)

HOT ROD CLADDING TEMPERATURE

Legend: 1d dwr — 1d dwrslpit — 3d dwr — 3d — EXPERIMENTAL VALUE

X-axis: TIME (s), Y-axis: TEMPERATURE (K)

2.2 General approach (2/2)

- <u>1d nodalization + unique downcomer</u> over predicts both peak cladding temperature and core quenching time

- <u>3d downcomer</u> does not provide better results than <u>1d nodalization + split downcomer</u>

- <u>3d nodalization</u> obtains the best estimation for the cladding peak temperature

3. Results

The main differences between the calculations regarding the cladding temperature are:

- **Blowdown peak value**

    much higher in the cases with 1d core

- **Core quenching time**

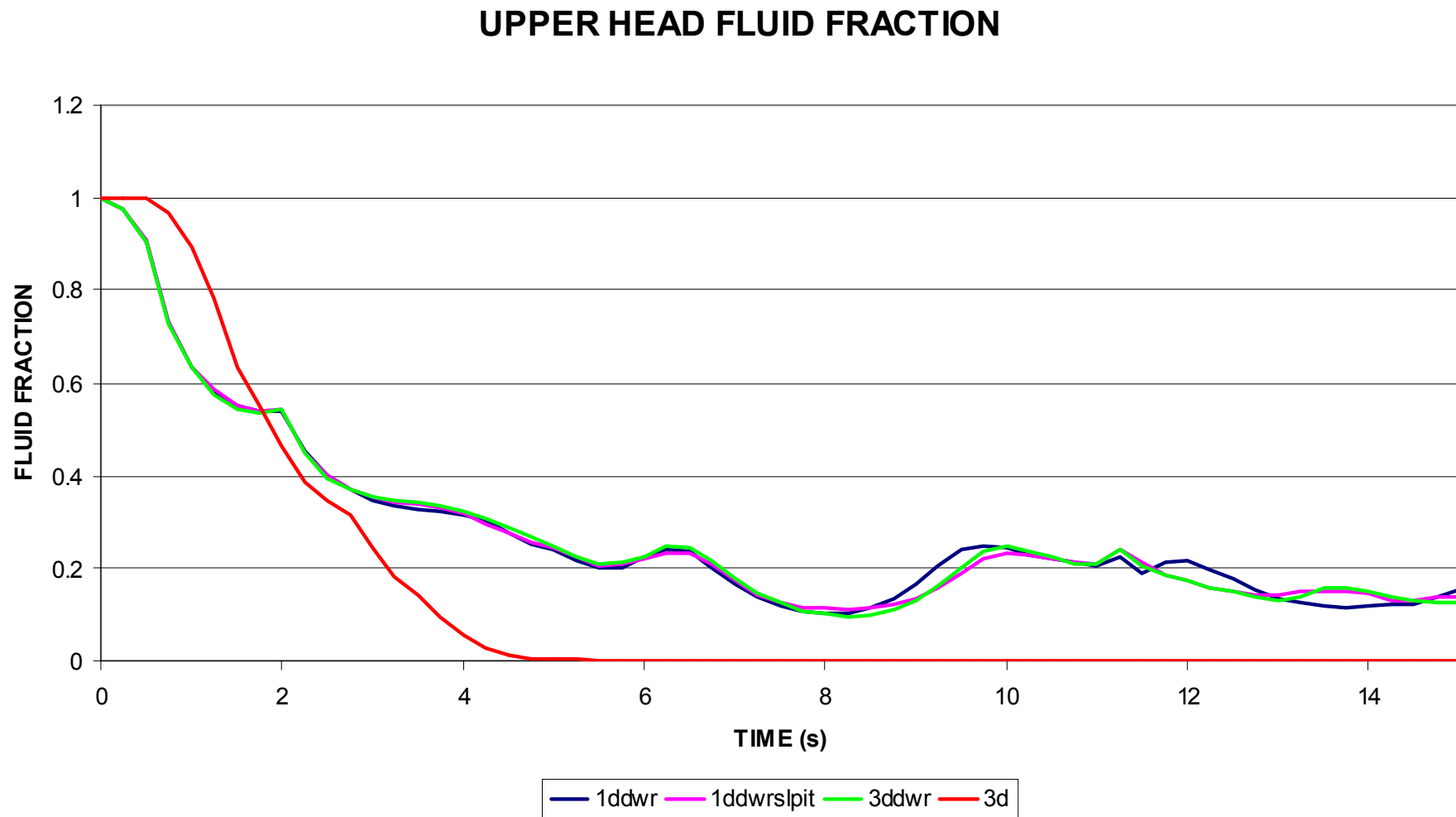   much larger in the 1d + unique downcomer case

None of the cases have the maximum peak cladding temperature in the reflood phase.

3.1 Blowdown peak (1/7)

- Differences in the blowdown peak temperature can be due to:

a. Short term core steam evacuation
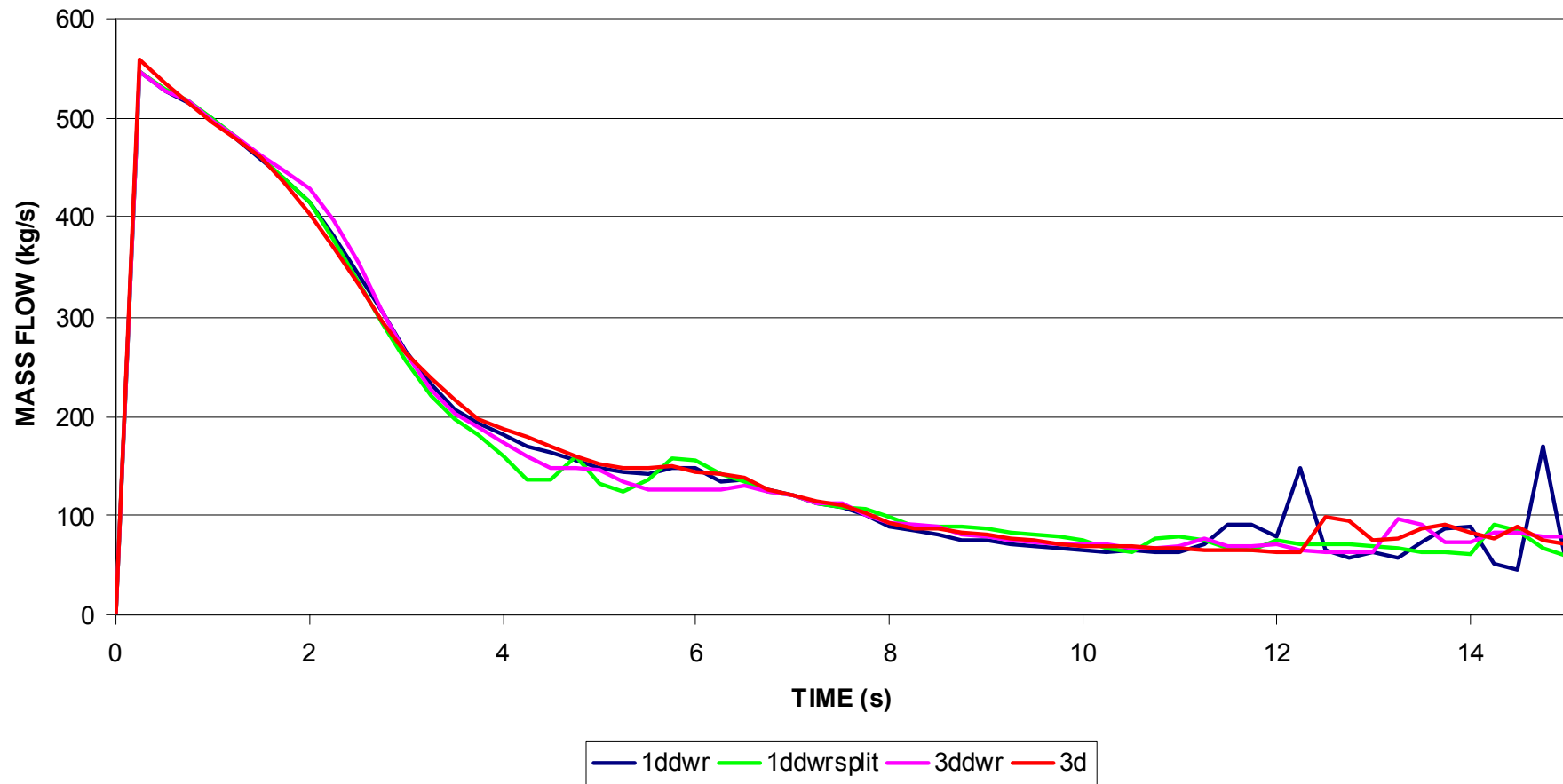
b. Radial and azimutal coolant velocities in the core

3.1 Blowdown peak (2/7)

UPPER HEAD FLUID FRACTION

3.1 Blowdown peak (3/7)

VAPOR MASS FLOW. BROKEN LOOP HOT LEG

Legend: 1ddwr, 1ddwrsplit, 3ddwr, 3d

a. <u>Short term core steam evacuation</u>

- As pointed out in previous studies, the upper head liquid fraction is greater in the 1d core cases.

- It was therefore expected that core steam evacuation in the short term would be underpredicted by the 1d models in comparison with the 3d models

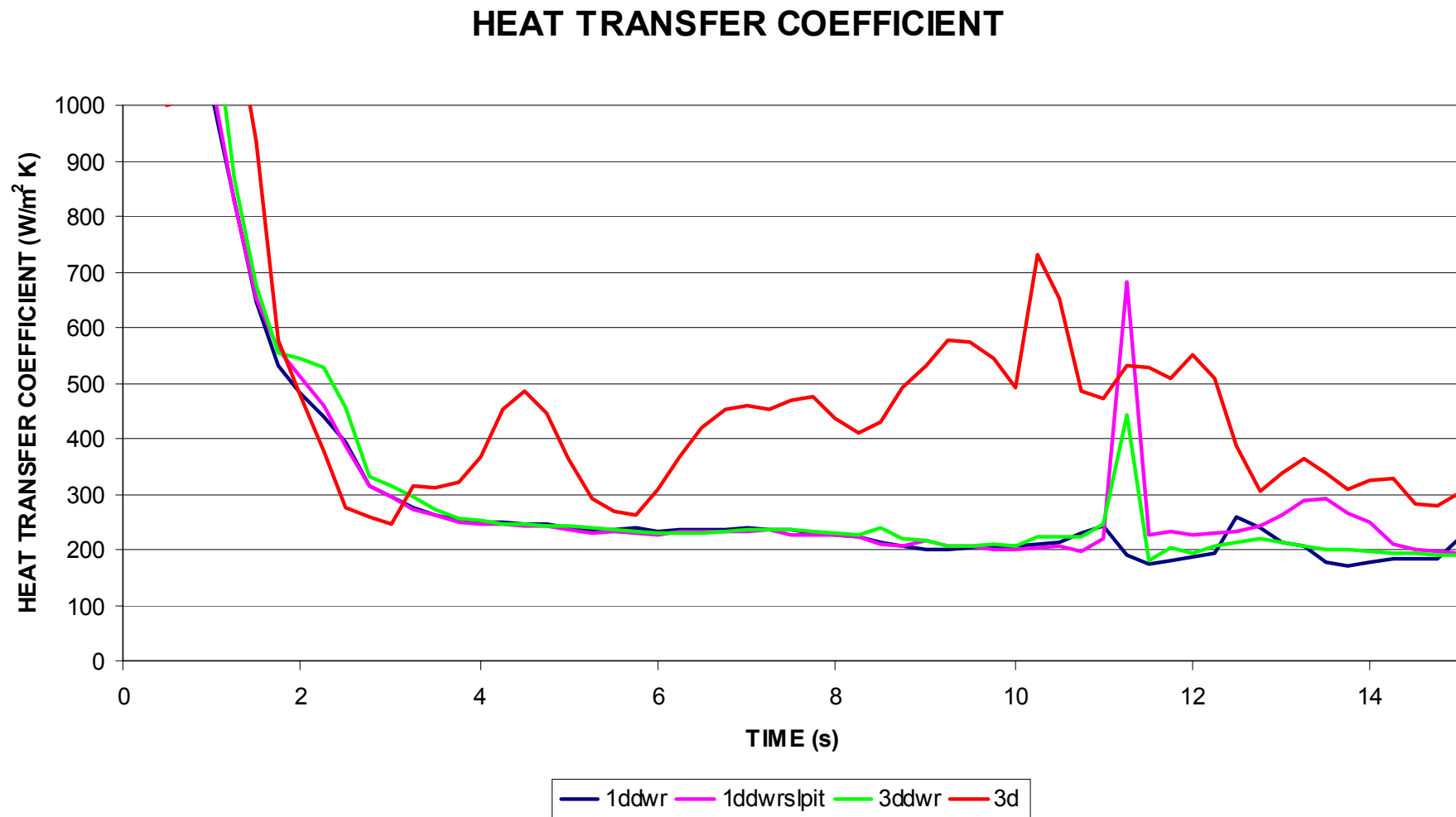<u>Plots **do not** show this phenomenon.</u>

3.1 Blowdown peak

- Differences in the blowdown peak temperature can be due to:

  a. Short term core steam evacuation

  b. Radial and azimutal coolant velocities in the core

3.1 Blowdown peak (6/7)

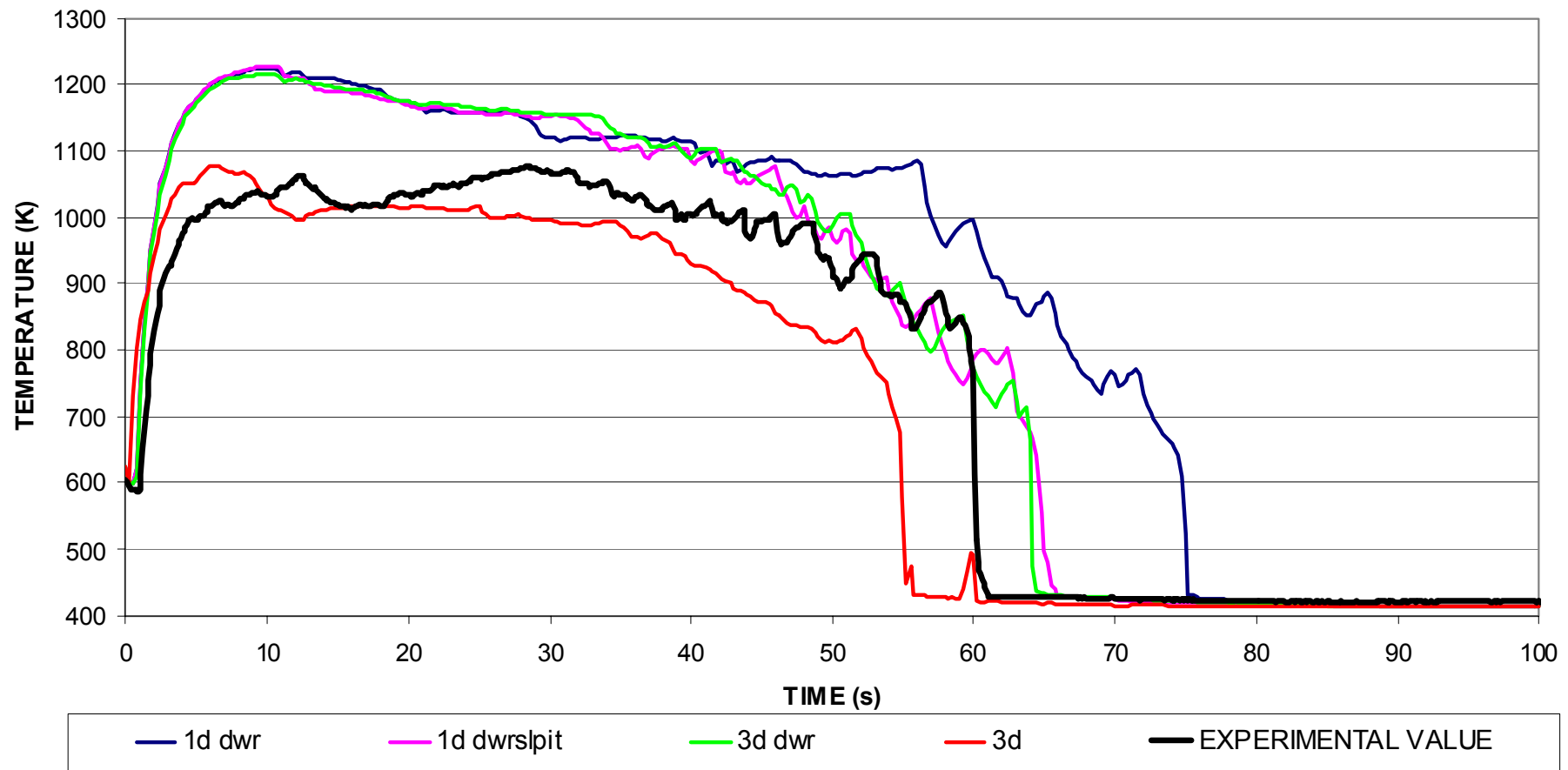**HEAT TRANSFER COEFFICIENT**

3.1 Blowdown peak (7/7)

b. <u>Radial and azimutal coolant velocities in the core</u>

The existence of flows in the radial and azimutal direction can only be modeled by the 3D nodalization.

The existence of such flows improve the heat transfer and therefore the core cooling.

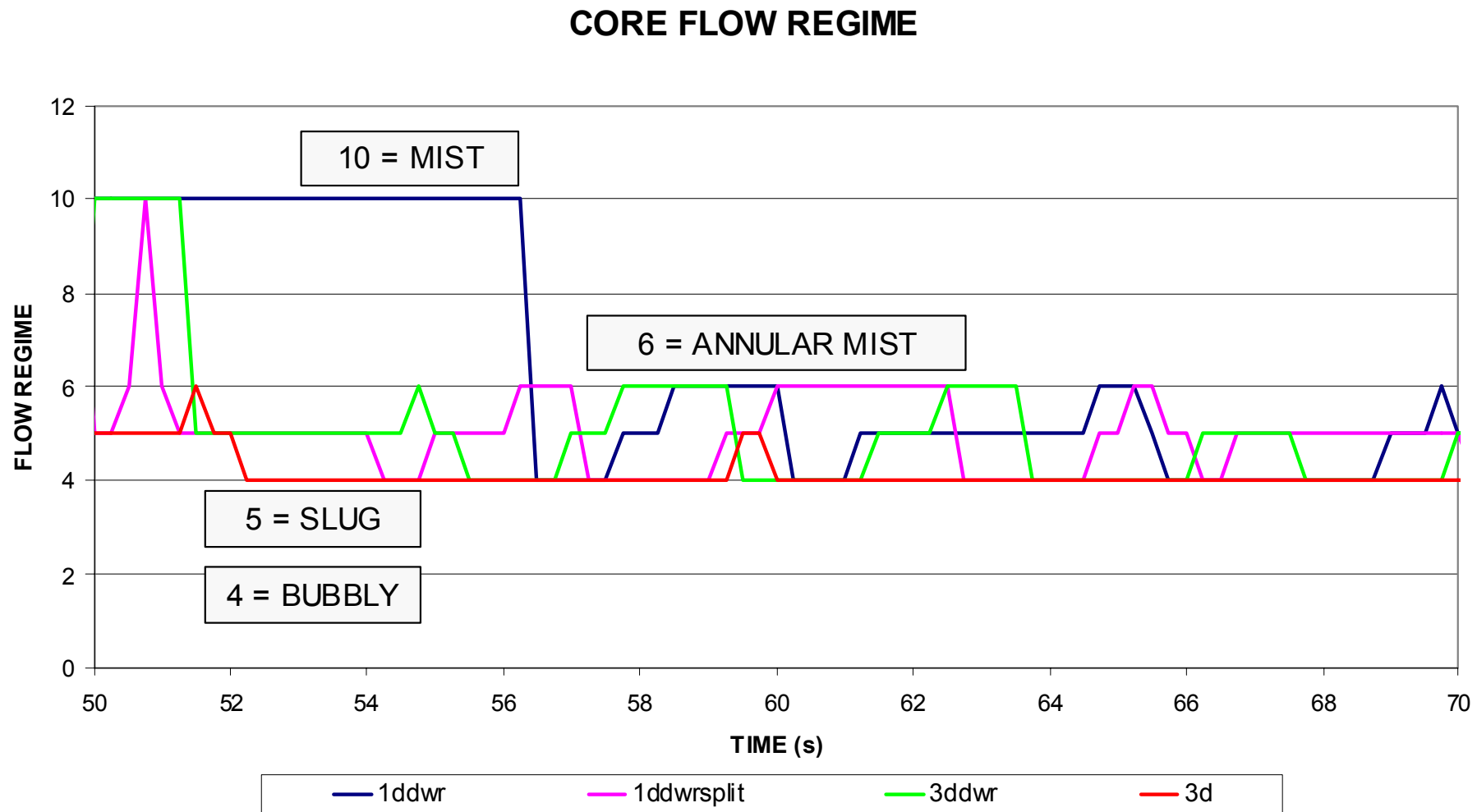# 3.2 Core quenching (1/9)

HOT ROD CLADDING TEMPERATURE

Legend: 1d dwr — 1d dwrslpit — 3d dwr — 3d — EXPERIMENTAL VALUE

3.2 Core quenching

- Differences in the core quenching time can be due to :

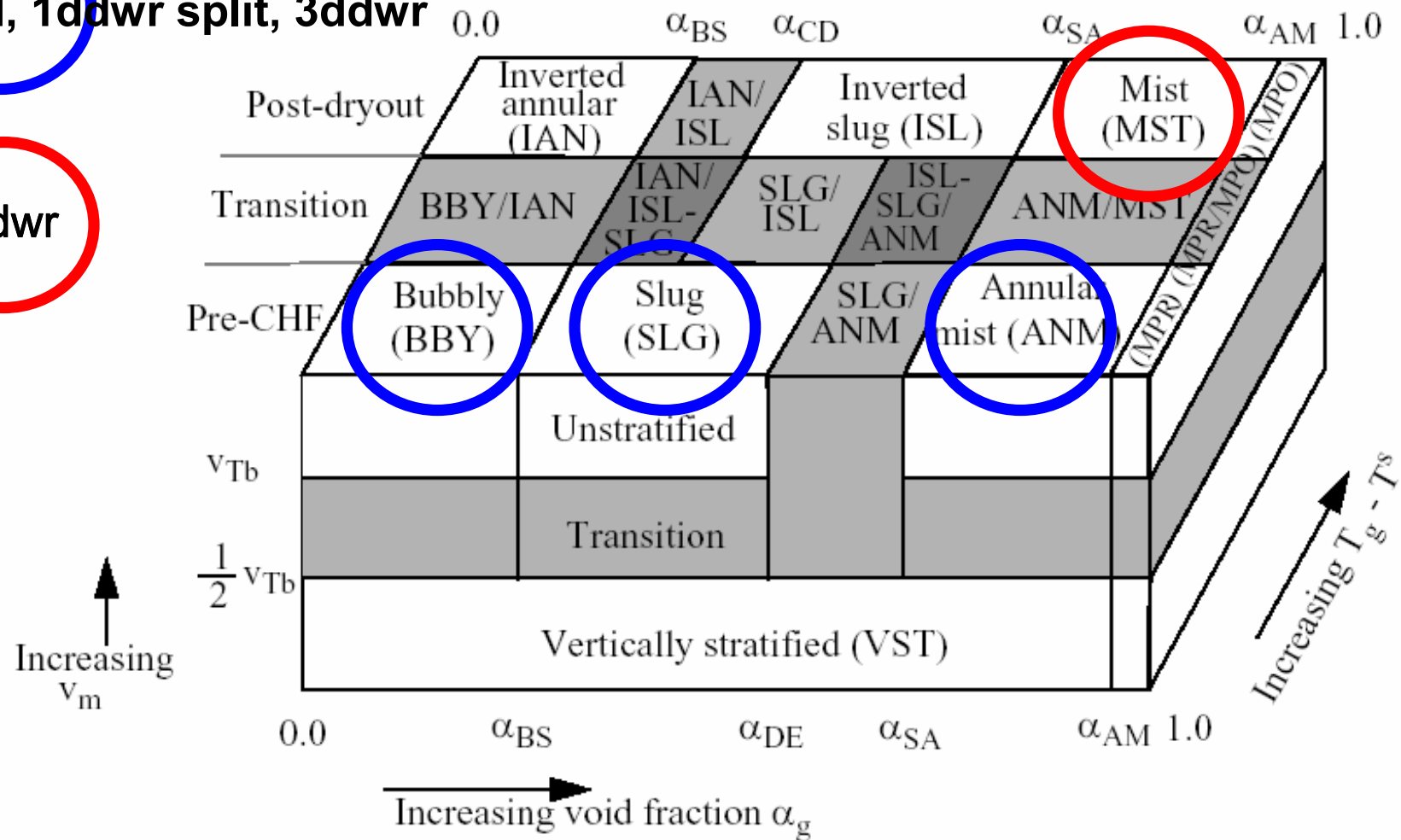 a. Flow pattern in the core
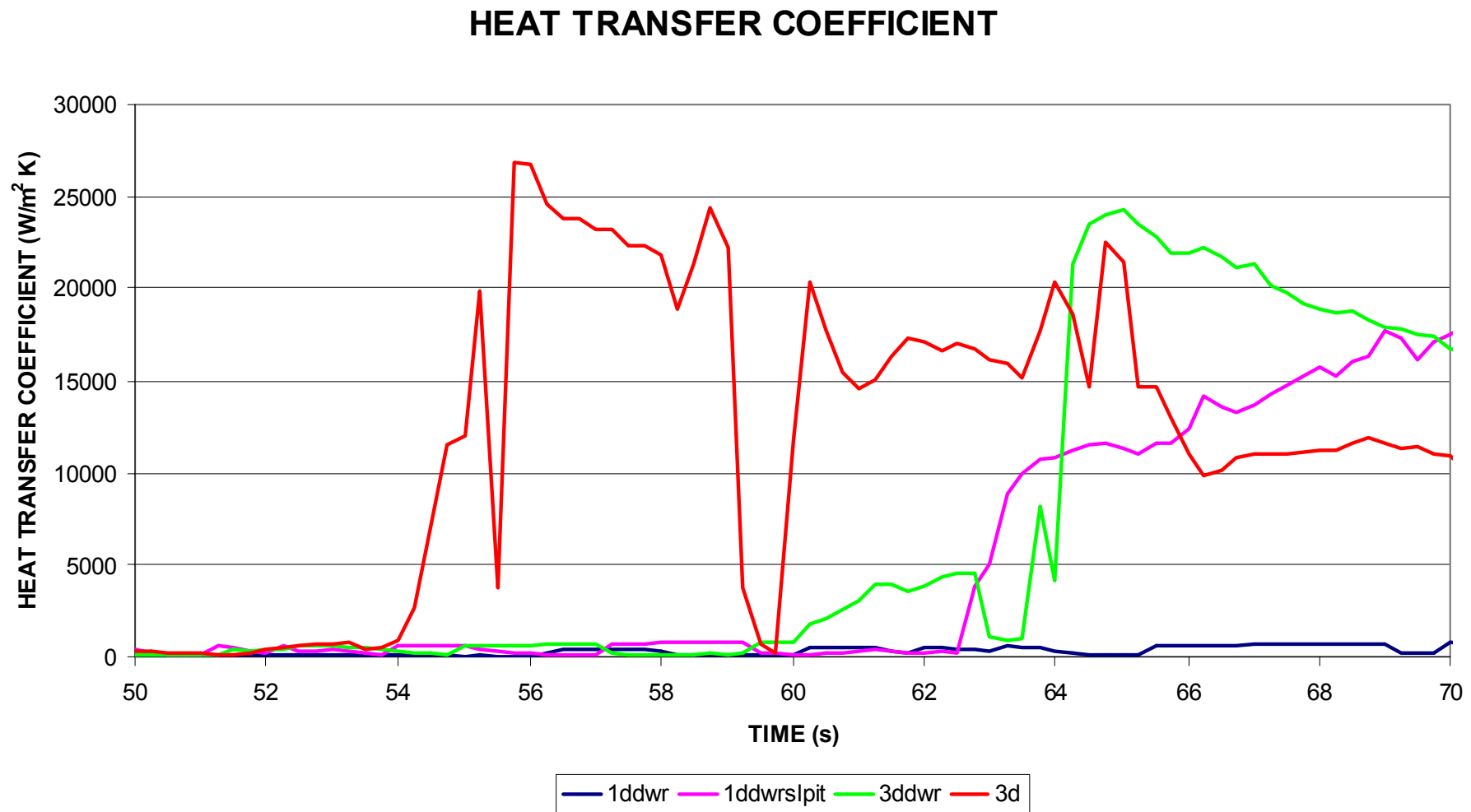
  b. Downcomer by-pass

CORE FLOW REGIME

3d, 1ddwr split, 3ddwr

1ddwr

3.2 Core quenching (5/9)

HEAT TRANSFER COEFFICIENT

In the <u>1d + unique dwr</u> calculation the core region stays longer in the mist flow pattern whereas in <u>3d, 3ddwr, 1ddwrsplit</u> other less degradated flow patterns are predicted earlier.
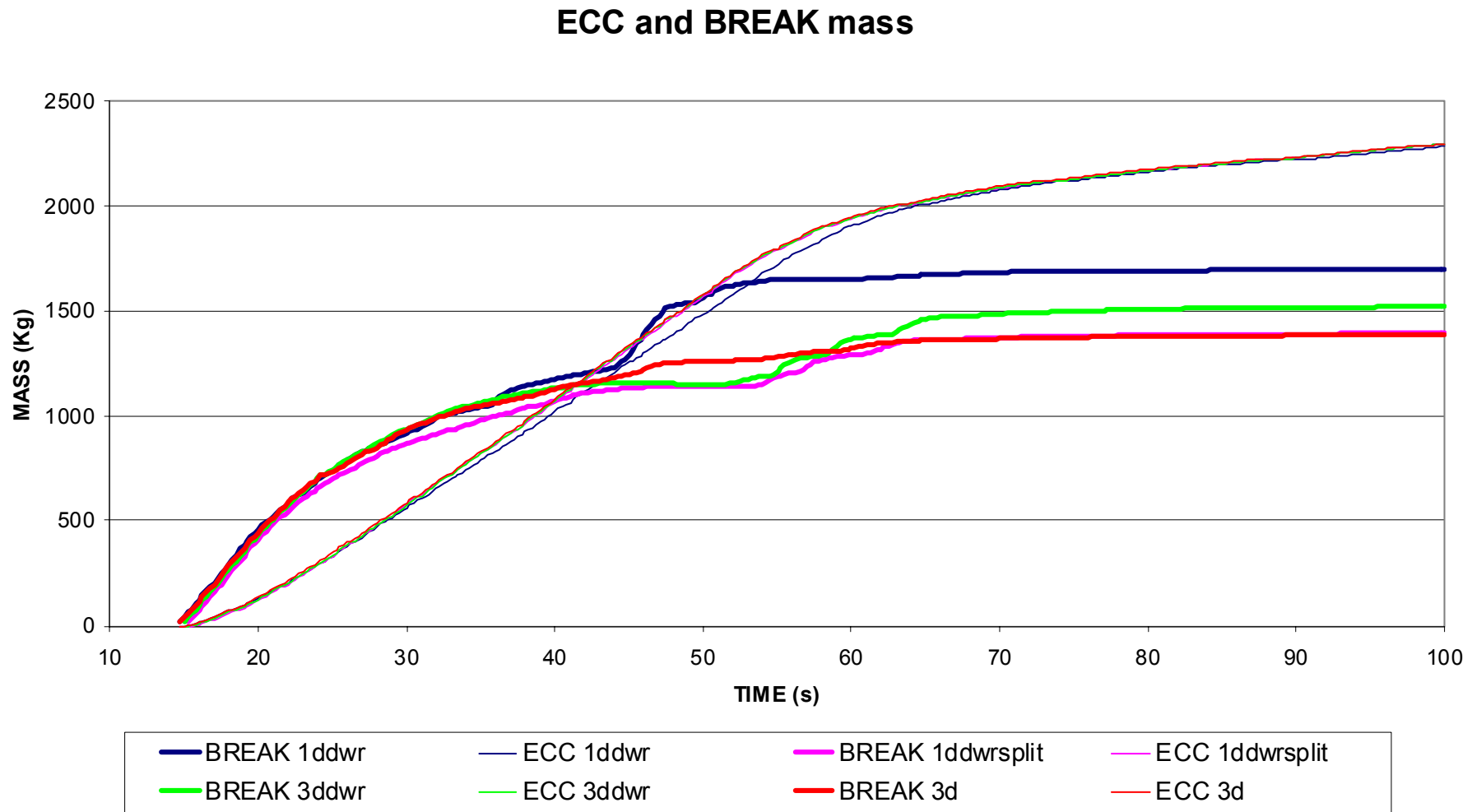
- Differences in the core quenching time can be due to :

  a. Flow pattern in the core

  b. Downcomer by-pass

3.2 Core quenching (8/9)

ECC and BREAK mass

In the <u>1d + unique dwr</u> calculation an important amount of eccs water is flowing directly to the break. This phenomenon is clearly less relevant in <u>3d, 3ddwr, 1ddwrsplit</u>.

4. Conclusions

- The 3d core nodalization obtains best results

- Downcomer bypass is significant in reflood phase but appears to be of less importance than expected

- Further study of the radial and azimutal core flows would enhance understanding of the core phenomena.